



Designation: F3576 – 22

Standard Practice for Recording the Exoskeleton Test Configuration¹

This standard is issued under the fixed designation F3576; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes a means to record the exoskeleton configuration when testing. This practice provides a method for recording exoskeleton hardware and software control parameters.

1.2 This practice: contextualizes the exoskeleton configuration during a test, including the identification and adjustment of main configuration parameters and the addition of other equipment (for example, cameras, markers) used during tests; provides a basis for comparison of the test circumstances across different exoskeletons or tests, or both (for example, varying power or spring settings, prior exoskeleton use, maximum control settings); and allows a test to be recreated.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are not precise mathematical conversions to imperial units. They are close approximate equivalents for the purpose of specifying exoskeleton characteristics while maintaining repeatability and reproducibility of the test method results. These values given in parentheses are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

¹ This practice is under the jurisdiction of ASTM Committee F48 on Exoskeletons and Exosuits and is the direct responsibility of Subcommittee F48.03 on Task Performance and Environmental Considerations.

Current edition approved Dec. 1, 2022. Published January 2023. DOI: 10.1520/F3576-22.

2. Referenced Documents

2.1 ASTM Standards:²

F3323 Terminology for Exoskeletons and Exosuits

F3613 Practice for Recording the Exoskeleton Fit to the User

F3614 Practice for Recording the Exoskeleton User Information

3. Terminology

3.1 Terms used within this standard refer to Terminology F3323.

4. Summary of Practice

4.1 This practice describes a method for recording the exoskeleton configuration when performing tests described in exoskeleton test methods. Without considering the variability of users, exoskeletons have a series of hardware and software parameters that can affect the exoskeleton functionality, for example:

4.1.1 Different exoskeletons, designed to help users perform varying tasks, may perform similarly due to their hardware setups or software capabilities and settings; or

4.1.2 The same exoskeleton models may be expected to perform similarly but instead perform differently due to their hardware setup and software settings.

4.2 The main configuration parameters are, for example:

4.2.1 *Hardware*—Exoskeleton weight, size, age, body part movement/support; and

4.2.2 *Software*—Control and monitor software, firmware versions, and software settings for maximum accelerations and velocities, maximum joint angle limits and torques, and sensor thresholds and impacts of reaching thresholds.

4.3 This practice also provides a standard method to report the exoskeleton configuration of which contextualizes exoskeleton test results. For example, the result of a timed test could

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

be dependent upon exoskeleton limitations on walking speed to 0.5 m/s or knee angle rotation limitation from 0° through 120°. As such, comparing two exoskeleton configurations could indicate that to which parameters affect exoskeleton performance.

4.4 This practice does not consider the user or the exoskeleton fit to the user information. These are also two important exoskeleton safety and performance areas that are discussed in Practice **F3614** and Practice **F3613**, respectively.

5. Significance and Use

5.1 The significance of the information to be recorded in a test report allows for exoskeleton safety and performance to be contextualized with the exoskeleton configuration. Exoskeleton tests can also be replicated across similar or different exoskeletons by using this practice to record the exoskeleton test configuration in a standardized way.

5.2 Limitations of the practice are that not all exoskeletons have the same capabilities or configuration parameters. For example, for capabilities, an exoskeleton that moves the legs with electromyography during rehabilitation may behave differently in repeated use over time or within different gait courses (for example, straight or curved). For configuration, an exoskeleton that moves the legs with electromyography during rehabilitation may have varying signal gain/amplification settings.

6. Exoskeleton Information

6.1 *Exoskeleton Photos*—Provide photographs, videos of motion, or computer aided drawings, or combinations thereof, of the exoskeleton front, sides, and back and any other distinguishing features.

6.2 *Main Exoskeleton Hardware Parameters:*

6.2.1 *Make and Model*—Provide the manufacturer and model of the exoskeleton, and mark any and all user's body areas that are intended to be affected by the exoskeleton, including: neck, shoulder, arm, hand, back, leg, ankle, or any other user's body area.

6.2.2 *Part Number(s)*—Provide the part numbers for each of the components, including: neck, shoulder, arm, hand, back, leg, ankle, or other user's body areas.

6.2.3 *Serial Number(s)*—Provide the serial numbers for each of the components, including: neck, shoulder, arm, hand, back, leg, ankle, or other user's body areas.

6.2.4 *Hardware Revision/Version*—Provide any revision or version numbers for each of the components, including: neck, shoulder, arm, hand, back, leg, ankle, or other user's body areas.

6.2.5 *Age (Years, Months, Runtime)*—Provide the age of the exoskeleton in years, months, and the amount of runtime (in hours) the exoskeleton has been used.

6.2.6 *Environment(s)*—Provide the environment in which the exoskeleton was used (for example, harsh outdoors, mud, rain, and temperatures between 5 °C and 35 °C).

6.2.7 *Classification*—Provide the main classification for the exoskeleton including, for example, the upper body, lower body, or whole body. If the classification is only by the exoskeleton affected area, select one of the following: neck,

shoulder, arm, hand, back, leg, or ankle, or provide any other user's body area(s) affected.

6.2.8 *Weight*—Provide the exoskeleton weight in kilograms, including all components necessary for a fully functional exoskeleton.

6.2.9 *Load Transmission to the Ground*—Provide whether or not the load applied to the exoskeleton (for example, the user's weight) is transmitted to the ground (that is, yes) or not (that is, no).

6.2.10 *Type*—Provide the exoskeleton powered type as: full active (that is, not user-powered), full passive (that is, user-powered), or hybrid (that is, a combination of actively and passively powered).

6.2.11 *Hybrid Joint Power Method*—Provide the exoskeleton hybrid power method for each component (that is, neck, shoulder, arm, hand, back, leg, ankle) as active or passive.

6.2.12 *Spring Selection*—Provide the spring, spring cartridge, or other peak spring force (Nm) settings for the neck, shoulder, arm, hand, back, leg, ankle, or other exoskeleton components (provide the component).

6.3 *Size Settings:*

6.3.1 *Generic Size*—Provide the generic exoskeleton size, if used by the manufacturer (for example, small, medium, or large). In all cases, if known, actual sizes and settings should also be provided (for example, shoulder-to-elbow length equals XX cm, etc.).

6.3.2 *Right/Left Side*—Provide the exoskeleton's size settings by listing or by copy/pasting into the spaces provided (see **Fig. 1** for examples).

6.4 *Control and Power:*

6.4.1 *Control Method*—Provide the exoskeleton control method for each component (that is, neck, shoulder, arm, hand, back, leg, ankle) or other exoskeleton components (provide the component) as active (that is, exoskeleton-powered) or passive (that is, user-powered).

6.4.2 *Range of Motion Limit Method*—Provide if the range of motion is limited by hardware or software.

6.4.3 *Range of Motion*—Provide the exoskeleton range of motion for each component: neck, shoulder, arm, hand, back, leg, ankle, or other exoskeleton components (provide the component).

6.4.4 *Power Source*—Provide the exoskeleton power method as onboard battery or tethered.

6.4.5 *Battery Percentage (start/end)*—Provide the exoskeleton battery percentage at the start and end of the test.

6.4.6 *Percentage of Power Settings*—Provide the exoskeleton power settings for each component: neck, shoulder, arm, hand, back, leg, ankle, or other exoskeleton components (provide the component).

6.4.7 *Sensors/Sensor Used for*—Provide the exoskeleton sensor(s) and use of the sensor(s) (for example, angle limit sensor, wall detection sensor, hazard sensor).

6.5 *Main Exoskeleton Software Parameters:*

6.5.1 *All Applicable Software and Firmware Versions (Component/Version)*—Provide the version(s) of any software or firmware used to control exoskeleton components or the full exoskeleton.